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ORIGINAL ARTICLES

THE DIAPHRAGMATIC RESPIRATION RECORDED BY A SYNCHRONOUS PNEUMOGRAPH*

By ALBERT H. MILLER, M.D.

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In 1754, the diaphragm was described as "a large, robust, musculous membrane or skin, placed transversely in the trunk, and dividing the thorax from the abdomen, whence the Latin writers call it septum transversum. The uses of the diaphragm are: first, to assist in respiration, for in taking in the breath, it is pressed downwards, and in expiration, it rises upward into the cavity of the thorax; secondly, to assist the necessary motions of the contents of the abdomen, viz., of the stomach, intestines, liver, and spleen; and lastly, for assisting the expulsion of the faeces, the urine, the foetus in parturition, and of the secundines."⁵

The definition of 1754 is, in the main, accurate at the present time. The diaphragm is the principal muscle of respiration. It is attached to the inner surface of the six or seven lower ribs, to the ensiform in front and to the vertebral column behind. Its dome is supported by the mediastinum. By its contraction, not only is the vertical diameter of the thorax increased but its lateral expansion is widened in consequence of lifting the obliquely placed lower ribs. The nerve supply of the diaphragm is provided by the two phrenics and the autonomic phrenic plexus. It can be stated without great exaggeration that impulses which activate the reflex arc of which the diaphragm is the terminus may arise in any of the sensory nerve endings.

While the work of the diaphragm is not open for inspection, its movements are transmitted unmodified to the abdominal wall by the semi-solid and liquid abdominal contents. The terms abdominal breathing and diaphragmatic breathing may be used synonymously.

The Synchronous Pneumograph

The synchronous pneumograph is an instrument devised to register independently the diaphragmatic

and thoracic respiratory movements. The applicators constantly measure the circumference of the chest and of the abdomen and register the increase and diminution in these measurements which result from the respiratory movements. Each of the applicators consists of two measuring tapes, one rigid and inextensible, the other elastic and extensible. Comparative variations in the length of these measures show very exactly changes in the circumference of the object to which they are applied. For want of a better name, the applicators will be called stethometers or simply, meters. The upper meter encircles the chest at any point but preferably at the level of the ensiform. The lower meter is fastened about the abdomen preferably about four inches below the ensiform. Each meter is connected to a pen by a silk cord which moves freely within a flexible tube. The pens follow exactly the changes in circumference of the chest and abdomen. They are arranged to write on paper supported on a drum which is rotated by clockwork at a known rate of speed.

With this apparatus we can demonstrate the normal types of respiration and the respiratory response to reflex stimuli. Normal respiration is of the mixed type with inspiration produced by synchronous contractions of the diaphragm and the thoracic muscles. Normal expiration is entirely passive. The respiratory rhythm is constantly modified by emotional stimuli and influenced by muscular movements and the operation of body functions. In the anesthetized patient we can show the irregular respiratory movements of the excitement stage, the automatic respiration of early surgical anesthesia, the progressive paralysis of the thoracic muscles of respiration and of the pneumogastric nerves, and the gradually failing diaphragmatic movements which herald approach to the stage of danger.

Respiration During Surgical Anesthesia

In the patient anesthetized to the surgical stage, we encounter the following types of respiration:

Diaphragmatic or abdominal,
Thoracic,
Delayed thoracic,
Reverse thoracic.

In the delayed thoracic type each thoracic inspira-

*Read before the Providence Medical Association, April 6, 1936.

tion begins late in the respiratory cycle as indicated by the movements of the diaphragm. As thoracic paralysis increases, each thoracic inspiration begins a little later until finally a diaphragmatic inspiration occurs with no corresponding thoracic movement. As the thoracic muscles become still further paralyzed, the thoracic movements are reversed so that each diaphragmatic contraction is accompanied by retraction of the chest wall. This condition is called reverse thoracic respiration. These changes in thoracic respiration are noted by the anesthetist by resting the thenar eminence of the hand on the patient's shoulder, or any other fixed point as the shoulder rest used for the Trendelenburg posture, and following the movements of the chest under the anesthetist's fingers. They are exactly recorded by the synchronous pneumograph.

It was about twelve years ago that it was first noticed by the writer that the breathing of an anesthetized patient seemed to be entirely abdominal, with no movement of the chest. Checking this observation in a series of cases, it appeared that all patients who were deeply etherized breathed entirely with the diaphragm and that their thoracic muscles were completely paralyzed. This was reported as an observation of interest if not of practical importance.⁴ McKesson checked a series of cases under nitrous oxide oxygen and found the thoracic respiration of these patients similarly paralyzed.³ Waters suggested that the point where thoracic respiration ceased be used to indicate the beginning of Guedel's third zone of the surgical stage of anesthesia.⁶

The Stages of Anesthesia

Guedel, having rounded out his previous extensive experience by intensive work in anesthesia during the great war, had classified the signs of anesthesia and combined them to make a chart which is of great assistance to the understanding of the progressive stages of anesthesia and for their practical management.¹ Following the suggestion of Waters, Guedel reclassified his signs of anesthesia to make the beginning of the third zone coincident with paralysis of the thoracic muscles.²

Under this classification, anesthesia progresses through four stages: The first or stage of analgesia; the period of induction during which the special senses, the perception of pain, and consciousness progressively fail until they are lost. The second or stage of excitement; reflex activity stimulated with a tendency to incoordinate response. The third or surgical stage; unconsciousness with diminished re-

flex activity progressing through four zones. The fourth or stage of respiratory paralysis; central paralysis of respiration finally overcoming the circulatory function and ending in death.



FIGURE I

Upper record, thoracic respiration. Lower record, abdominal respiration. Up stroke, inspiration. Down stroke, expiration. Timer marks ten seconds and minutes.

Transition from second to third zone of the surgical stage of anesthesia marked by paralysis of the thoracic muscles of respiration. Gradual narrowing of diaphragmatic movement tending toward fourth zone. Deep diaphragmatic inspiration with less thoracic movement indicates a sigh. It may occur under light or deep anesthesia.

The Four Zones of the Surgical Stage of Anesthesia

In the third or surgical stage, the first of the four zones is indicated by loss of the lid reflex. The respiration, which has been characterized by the incoordinate reflex response of the stage of excitement, becomes regular and machine like with increased amplitude and frequency. Inspiratory movements of the thorax equal or excel the movements of the diaphragm. Oculo-motor activity is indicated by rhythmic lateral oscillation of the eyeballs, by eccentric fixation of the eyeballs, or by sharp, irregular contractions of individual oculo-motor muscles.

The second of the zones of the surgical stage is noted on the cessation of oscillatory movements of the eyeball or of the other signs of oculo-motor activity. The rapid, automatic respiratory motions are at first carried on by thoracic muscles and diaphragm alike. As anesthesia deepens, the thoracic inspiration becomes more and more delayed until paralysis of the thoracic muscles indicates the beginning of the third zone.

The third zone of the surgical stage is characterized by complete paralysis of the thoracic muscles of respiration. The diaphragm takes up the work of respiration and carries it on as best it may. During anesthesia the diaphragm is often required to carry from ten to fifteen times its usual load. The thoracic muscles may become so flaccid that the chest wall retracts on inspiration, its framework sucked inwards by each contraction of the diaphragm. If the airway is allowed to become blocked, the collapse of the thorax on each attempted inspiration becomes even more evident.

The thoracic muscles of respiration receive their innervation from the twelve dorsal segments of the



FIGURE II

Upper record, thoracic respiration. Lower record, abdominal respiration. Up stroke, inspiration. Down stroke, expiration. Timer marks ten seconds and minutes.

Third stage, second zone ether anesthesia. Twice, the artificial airway is removed and the tongue allowed to fall back with complete respiratory obstruction resulting. The thoracic respiration immediately assumes the reverse type. The diaphragmatic movements continue but the partially paralyzed thoracic muscles allow the chest to collapse on each diaphragmatic inspiration. Both abdominal and thoracic movements seem active but are entirely ineffectual for introduction of air into the lungs. On replacing the airway the thoracic respiration is restored and a period of compensatory hyperpnea follows. Complete respiratory obstruction in this zone of anesthesia produces no pause in the diaphragmatic respiratory rhythm. In conjunction with the Hering-Breuer reflex, this indicates complete paralysis of the pneumogastric nerve.



FIGURE III

Upper record, thoracic respiration. Lower record, abdominal respiration. Up stroke, inspiration. Down stroke, expiration. Timer marks ten seconds and minutes.

Recovery from ether anesthesia. Respiration slower. On removing the artificial airway and allowing respiratory obstruction to occur, there is a tendency toward a pause in the diaphragmatic movement, more marked in the second trial which was made three minutes later than the first. In conjunction with the Hering-Breuer reflex, this indicates progressive recovery of the function of the pneumogastric nerve.

The shallow thoracic respiration becomes reversed while the airway is blocked. When the respiratory obstruction is relieved by introduction of an artificial airway, a period of compensatory hyperpnea follows.

spinal cord. The phrenic nerves, coming from the fourth cervical segment, originate nearer the brain and higher nerve centers. These facts alone would tend to prove the presence of an ascending paralysis, but taken in conjunction with the early paralysis of the pneumogastric, which has its nucleus in the floor of the fourth ventricle, they prove that the paralysis caused by anesthetics is selective in its effect.

The fourth zone of the surgical stage is initiated by beginning paralysis of the diaphragmatic respiration. Thoracic paralysis persists and the chest continues to retract with each diaphragmatic inspiration. The paralysis of the diaphragm is pro-

gressive, the contractions becoming less frequent and less effectual. The respiration steadily fails in volume and in rate until finally it ceases entirely, indicating the beginning of the fourth stage—the beginning of the end.

The signs of these four subdivisions of the surgical stage of anesthesia are clearly marked: the first zone by loss of the lid reflex and initiation of automatic respiration; the second by signs of oculomotor paralysis; the third by paralysis of thoracic respiration; the fourth by beginning paralysis of the diaphragmatic respiration, progressive through this zone until complete cessation of respiratory movement indicates the end of the fourth zone and entry into the fourth and final stage of anesthesia.

Conclusions

Paralysis of the thoracic muscles of respiration is the most valuable of the signs of anesthesia because it indicates the point in the surgical stage at which most serious operations can be most safely and efficiently performed.

For minor operations the first and second zones suffice. For most abdominal operations the point of transition from the second to the third zone is satisfactory. To secure freedom from reflex response to upper abdominal manipulations it is often necessary to push the anesthesia deeply into the third zone or even to the fourth zone. Although it is never advisable to disregard any sign or warning when administering an anesthetic, it is possible to maintain a light or deep anesthesia at a constant level by following the thoracic and diaphragmatic movements as recorded on the synchronous pneumograph. This has often been done for long operations in which it was required that the patient's head be covered and the face made inaccessible to the anesthetist. Aside from its practical application in anesthesia, the synchronous pneumograph opens a wide field for research on the physiology of respiration.

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EDITORIALS

THE RECENT OUTBREAK OF POLIOMYELITIS

The advancement in the management of cases of infantile paralysis has been evident following the recent outbreak of this disease in the State.

One of the outstanding results is the more rapid recovery and the return to usefulness of the involved arm or leg and the prevention of contractures, as compared with conditions following epi-

demics of the past. The prophylactic or serum treatment has proven disappointing, both the Brody and Kolmer methods, it is generally agreed, need further study.

The employment of trained physiotherapists working under the instruction of the attending physician has resulted in much better work than followed the treatment of twenty years ago. These happy results have been most gratifying to patients and doctors and if a treatment of the early stages and prophylaxis could be established, one of the most destructive and feared communicable diseases will have been controlled.

THE PROBLEM OF INFLUENZA

In the March 14th issue of the *Journal of the American Medical Association*, is an article on INFLUENZA. *Time*, the weekly newsmagazine, considered it newsworthy, sketched it briefly and accurately. How many of us missed it when the *Journal* was laid on our desk, to go back and reread it when efficient *Time* called it to our attention?

The article is the result of work done by three able young bacteriologists. They have concluded from this work that the virus of human influenza in widely separated areas appears to be a single immunologic entity. They found immune bodies to be present in the blood serum of convalescent Eskimos, and in the serum of about half the adult population of British and American cities. The authors feel that the pandemic of 1918 leaped the barrier from human to animal and now smoulders in the form of swine influenza, slightly modified.

Both active and passive immunization of susceptible animals against this virus have been affected. It is a careful, well written, and perhaps prophetic article. Medical men who did not see the ravages of the disease during the pandemic cannot conceive the dreadful havoc wrought. Does this article point at last, the road to eventual control of one of mankind's scourges, outranking wars in its death toll? The footnotes of this article promise further papers. We look forward to more such readable, important reports.

LOOK AND SEE

At intervals the RHODE ISLAND MEDICAL JOURNAL has called attention to the dangers to the public and to the medical profession of socialized medicine. The JOURNAL still feels the profession has not fully acquainted itself with these dangers and therefore is not prepared to inform the public intelligently about them.

The Providence Medical Society has secured a large number of copies of the various publications of the American Medical Association on the subject and has supplied most of its members with these pamphlets. A few are left for distribution.

It is not enough, however, to give out reading matter. The important thing for every member of the medical organizations is to read the literature supplied. If the laity is to be given information and

THE JOURNAL'S COLUMN

To insure prompt attention, the readers of this JOURNAL are advised: That matters pertaining to advertising, mailing and accounts should be addressed the Business Manager, Dr. C. W. Skelton, 106 Francis Street, Providence, R. I.

Other matters, books for review, notices, manuscript, letters, reports of meetings, and all affairs of literary nature should be addressed to the Editor, Dr. Frederick N. Brown, 309 Olney Street, Providence, R. I.

AS TO BOOK REVIEWS

Books received for review are the property of the Rhode Island Medical Society.

Inasmuch as it is a compliment to be asked to review a scientific book, it is to be hoped in courtesy to the publishers that the review may be finished within a period of thirty days, the book sent to the Society's library and review to the Editor.

Should sixty days elapse before receipt of book (and review) the matter must be referred to the discretionary action of the Society in the recovery of its property.

"Letters to the Editor" are considered to be the personal expression of the writer's opinion upon the subject of which he writes.

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through them the law-makers of both state and nation, the informants must prepare themselves. Read the literature!

OUR PERENNIAL NUISANCE

Again the thought of the noisome Providence River and its tributaries appears in the daily papers, from which we may conclude that these problems are still unsolved. Some forty years ago a writer suggested that a boatman armed with a pole make a crude investigation by proceeding up these streams and, by thrusting the pole down into the mud, learn something of the cause of the nuisance, well known to many visitors to this fine city. At that time the writer was urged to appear before the then State Board of Health to demonstrate his views

and suspicions but, seeking to avoid trouble, rather than to seek it, he declined with many thanks. What has been done since we do not know and there seems to be no way to find out. But we venture to say that despite the cleaning out and scouring that may have been occasioned by the unusual flood condition which have recently prevailed it may be quite possible that the coming hot weather will still reveal a sluggish, dirty stream in the midst of a fair city in which frequent bubbles of ill smelling gas will occasionally come to the surface of the slowly moving waters, burst and discharge their contents into the atmospheric air.

Again it was not long ago that a circular letter was sent to members of the medical profession asking if they had ever noticed the odors of gasoline distillation in the air and the writer offered to conduct the authorities to the very spot from which these odors proceeded. No reply was received from this polite and very definite offer. The time has now arrived when we shall be obliged to keep our windows open and unless matters have changed within a very short time we shall again be able to note most disagreeable odors from the oil distilleries which constitute a distinct offense and a nuisance.

The intervention of the medical profession in these matters is a distinct duty. The remedy of these matters should present no considerable engineering difficulties. They have precipitated no epidemics: comfort rather than life is disturbed, but we physicians have not only to deal with hysterectomies, abdominal sections and other valuable considerations, but we should throw the weight of our influence to every cause which affects not only the public health but its well being.

Fresh sewage is a clean crystalline and beautiful thing compared with the waters of the Providence River, and the out house of our forefathers is considered by many to be far more bearable than the odors in which we often try to sleep throughout the night. Perhaps some scientific investigators will find out for us if there is some connection between these things and prevalent sore throats, bronchitis and the inadequate ventilation which these nuisances impose upon us.

BOOK REVIEWS

SYNOPSIS OF CLINICAL LABORATORY METHODS. By W. E. Bray, Professor of Clinical Pathology, University of Virginia. C. V. Mosby Co., St. Louis, Publishers, 1936.

"The object of this synopsis is to bring together in a small volume for ready reference the more recent information and the most frequently used methods of laboratory diagnosis" — author's preface.

The author covers the fields of urinalysis, hematology, blood chemistry, gastric analysis, feces and intestinal parasites, puncture and cerebrospinal fluid examination, sputum, general bacteriology, serology, rather exhaustively for the size of the book and has given the essentials of water and milk examination, basal metabolism tests, allergy tests, poisons and foreign substances, and surgical pathology in other chapters. The last chapter gives stain formulae, directions for making solutions, removal of stains and tables of normals, atomic weights and equivalents.

Clear and concise directions are given for each procedure, and in many cases improvements are incorporated in the original methods.

The book is up-to-date as evidenced by inclusion of such recent developments as the one hour two-dose dextrose tolerance test, sternal marrow examination, Neufeld pneumococcus typing, Kline slide test for syphilis, Wassermann test interpretation according to the 1935 survey, and Dioxan as a dehydrating reagent in histological preparations.

The index is complete but not cumbersome, the section on poisons is a welcome addition, and there is sufficient interpretation of results given to suggest applications and aid in evaluating results.

As a whole the book is a valuable contribution to laboratory science.

W. E. B.

MARTINI'S PRINCIPLES AND PRACTICE OF PHYSICAL DIAGNOSIS. Edited by Robert F. Loeb, M.D. From authorized translation by George J. Farber, M.D. Published by J. B. Lippincott Co.

The subject of physical diagnosis is rationally and logically presented in this translation of Professor Paul Martini's text.

The book is devoted to the technique of examining the patient by the four cardinal methods—inspection, palpation, percussion and auscultation. The book is short yet complete. There are four chapters; one devoted to observation of the patient, one to the respiratory tract, one to the circulatory system and one to the examination of the abdominal organs.

There is a brief review of the anatomy and physiology of the respiratory and circulatory systems. A few simple physical principles are explained which make the findings derived from percussion and auscultation simple and logical.

The approach and manner of presenting the various subjects are different, clear and altogether instructive. Although primarily for the student, the book helps the practicing physician to better evaluate his physical findings.

Hughes: Practice of Medicine, Gordon. 15th Edition. Blackiston. Is a book written chiefly for the practitioner of general medicine. It covers about the entire field of medical diseases. The material has been arranged concisely and systematically, which makes the book particularly attractive to the busy doctor.

Considerable space is devoted to symptomatology and pathology. The subject matter has been revised and brought up to date.

The English is excellent as is the print.

Recommended especially for diagnostic work.

SOCIETIES

RHODE ISLAND MEDICAL SOCIETY

The regular quarterly meeting of the Rhode Island Medical Society was held Thursday, March 5, 1936, at the R. I. Medical Library Building, and was called to order by the President, Dr. Roland Hammond, at 4 P. M.

The minutes of the February meeting of the Council, and of the House of Delegates, were read by the Secretary and approved.

The President announced the death of: Dr. Franklin P. Capron, who died Dec. 16, 1935, and Dr. R. Herbert Carver, who died Dec. 30, 1935, and referred the matter to the Committee on Necrology for a report at the annual meeting.

The following program was presented:

1. "Treatment of Fracture of the Neck of the Femur," William A. Horan. Discussion by E. S. Cameron.

2. "Peroral Endoscopy as an Aid in the Diagnosis of Diseases of the Bronchi and Oesophagus,"

Linley C. Happ. Discussion by Gordon McCurdy, J. M. Beardsley, John Langdon, L. C. Happ.

3. Motion Picture Film, "Modern Methods of Anesthesia." This film, prepared and furnished by the Winthrop Chemical Co., was projected by Dr. Meyer Saklad. The film showed the preparation and administration of Avertin and of Evipal, and also showed the technique of spinal anesthesia by novocain.

After adjournment a collation was served.

Respectfully submitted,

J. W. LEECH, *Secretary*

SPECIAL MEETING—HOUSE OF DELEGATES

March 20, 1936.

A special meeting of the House of Delegates was held March 20, 1936, at the Medical Library.

The following resolution was read by the secretary:

"Resolved, That whereas there is recognized a real need for measures looking to the recognition and control of tuberculosis and to the advancement of mental hygiene throughout the state; and

Whereas, The installation of clinics and surveys to accomplish these purposes at the request of hospitals, clinics and lay organizations is often accompanied by requests that the Public Welfare Commission of the State of Rhode Island use its facilities and personnel for the above purposes,

Be it Resolved, That the Rhode Island Medical Society approves the installation of clinics and surveys for the above purposes where they are safeguarded by the following provisions:

1. Requests for clinics and surveys for the control of tuberculosis and advancement of mental hygiene should come through hospitals, clinics or medical members of lay groups.

2. The personnel of the departments of Public Welfare Commission shall act only in an advisory and consultative capacity.

3. Reports of these activities of said departments of Public Welfare Commission, dealing as they do with medical problems, shall be rendered to the appropriate physician or physicians requesting the installation, and not to lay representatives of the organization requesting the technical services of said departments of Public Welfare Commission."

The President, Dr. Roland Hammond, explained that the above resolution was inspired by the situation which had arisen in connection with a proposed survey of high school pupils in East Providence by the Rhode Island Anti-Tuberculosis Association. This organization proposed to conduct such a survey by making use of the clinical personnel of the R. I. State Sanatorium at Wallum Lake. The Public Welfare Commission called a conference of the President, and Secretary of the R. I. Medical Society, the President of the Providence Medical Association, Dr. V. H. Danford, superintendent of the Wallum Lake Sanatorium, and Mr. Chandler, Executive Secretary of the R. I. Anti-Tuberculosis Association. It was found that the survey had been instituted without the knowledge of, or reference to the school physicians of East Providence. It was found impossible for the personnel of the State Sanatorium to devote the time necessary for the actual X-ray examination of the 600 children, and it was felt that the activities of the medical staff of the State Sanatorium in his survey could not include more than the reading of the X-ray films, and the issuance of reports thereon.

It was moved and seconded that the resolution be adopted. It was so voted.

The President pointed out the duty of the medical profession in bringing to the notice of the public the dangers of socialized medicine. He pointed out that other State Medical Societies had organized groups of speakers to address the civic clubs, such as the Rotary, Kiwanis, Lions, Parent-Teacher's organizations, etc., in order to bring to the public a knowledge of socialized medicine.

It was moved and seconded that the President be empowered to appoint a committee of five to arrange for speakers to address such lay organizations in regard to socialized medicine. It was so voted.

Adjourned.

Respectfully submitted,

J. W. LEECH, M.D., *Sec'y.*

PROVIDENCE MEDICAL ASSOCIATION

The regular monthly meeting of the Providence Medical Association was called to order by the president, Dr. William S. Streker, on Monday evening, March 2, 1936, at 8:45 P. M. The minutes of the last meeting were read and accepted. The

secretary read a letter from the postmaster of Providence calling attention to medical and surgical equipment for sale by the Post Office Department.

The President announced a request from the Red Cross Society that a Medical Sub-committee of the Red Cross Disaster Committee be appointed to act in time of disaster.

The first paper of the evening was read by Dr. J. Murray Beardsley, and was entitled "Bronchiectasis." It was based on a study of 40 cases observed over a period from one to twelve years. The diagnosis was proven in each case by injection with lipiodol. The condition may be congenital or acquired. Infection and pressure act as causative factors. There may be sacculated or tubular types or mixed types. In the 40 patients studied there were eight cases of the mixed type and 16 cases of each of the other two types. There were 24 males and 16 females. The majority of the cases were in the second and third decades, there being 12 patients in each of these two age groups. There are no distinctive symptoms or signs. Lipiodol injection is the most important and useful diagnostic aid. Routine X-rays without lipiodol injection are of very little help. Of the 40 cases studied five had been in tuberculosis sanatoria but had had persistently negative sputa. No bacteriological studies were made. Dr. Beardsley concluded by showing lantern slides of X-ray pictures illustrating types of bronchiectasis and showing results of treatment particularly by use of pneumothorax.

The next paper was read by Dr. John T. Farrell, Jr., of Philadelphia and was entitled "The Roentgenologic Differential Diagnosis of Non-Tuberculous Diseases of the Lungs." Dr. Farrell began by pointing out that the diagnosis of tuberculosis is too frequently made in patients who have later been proven to have non-tuberculous disease of the lungs.

The speaker then discussed the mechanisms by which changes in the X-ray appearance of the lungs may be produced, and illustrated his talk throughout by lantern slides showing many examples of the various disorders produced. Such changes may be due to (1) infection by bacteria; (2) to bacterial infection plus obstruction; (3) or to mechanical obstructive lesions without infection.

Dr. Farrell spoke briefly of the physiology of normal respiration and discussed the types of bronchial occlusion produced by foreign bodies,

tumors, etc., and showed X-ray pictures illustrating types of changes produced in the lungs in various conditions. He continued with a discussion appearance metastatic or secondary tumors of the lungs in which the nodules are usually sharply circumscribed and scattered diffusely throughout the lung. He concluded with a discussion of results of trauma and pressure from extra-bronchial lesions.

The papers were discussed by Drs. Happ, Boyd, Caron, J. G. Kelley, Ham, William McLaughlin, F. B. Cutts and McCurdy.

The meeting adjourned at 10:50 P. M. Collation was served.

Respectfully submitted,

HERMAN A. LAWSON,
Secretary.

PAWTUCKET MEDICAL ASSOCIATION

March 19, 1936.

The annual meeting and banquet of the Pawtucket Medical Association was held on March 19, 1936, at the Slater Hotel in Pawtucket, R. I., at 7:30 P. M.

Forty members and ten guests attended. The guests were Dr. Wm. Streker, president of the Providence Medical Society; Dr. R. Hammond, president of the Rhode Island Medical Association; Dr. B. Campbell Beard, professor of political economics at Brown University; Drs. K. Barr, Greenstein, Jones, Eddy, Lalonde, Shaw, and Hussey. Dr. James L. Wheaton served as toastmaster. Dr. B. Campbell Beard was the chief speaker of the evening and gave a very interesting talk on the "Present European Situation." Dr. Wheaton presented Dr. George Howe, who has attended every annual banquet since 1905.

The regular business meeting was called to order at 9:30 P. M. by Dr. Dufresne, the president. Reports of the officers and various committees were presented and accepted. Dr. Barnes was elected unanimously a regular member.

Officers for the following year were elected: President, Dr. W. J. Dufresne; vice president, Dr. E. A. Cormier; secretary, Dr. T. A. Krolicki; treasurer, Dr. B. U. Richards; delegates to Rhode Island Medical Society, Dr. C. L. Farrell, Dr. G. R. Fox, Dr. S. Sprague, Dr. R. T. Henry; library committee, Dr. G. Howe, Dr. E. Mathewson, Dr.

J. B. Marshall; standing committee, Dr. E. Kelly; councillor, Dr. C. Holt.

Other routine and new business was transacted. Meeting adjourned at 12:30 A. M.

THAD. A. KROLICKI, M.D.,
Secretary.

SPECIAL STATEMENT

Physicians interested in a public health career and desiring the opportunity to train for such a career may apply to Dr. Edward A. McLaughlin, Room 319, State Office Building, Providence, Rhode Island.

In accordance with provisions of the Social Security Act, scholarships are to be issued through the State Departments of Public Health for this purpose.

Physicians interested in this opportunity should address all communications to Edward A. McLaughlin, M.D., Room 319, State Office Building, Providence, Rhode Island.

ANNOUNCEMENTS

Dr. William P. Buffum announces that in addition to his general pediatric practice, he will give especial attention to problems of allergy and asthma in childhood.

Dr. Francis L. Burns announces the opening of his office at 568 Broad Street, Providence, for the practice of diseases of ear, nose and throat.

POLYPOSIS OF COLON

George E. W. Hardy, Tampa, Fla. (*Journal A. M. A.*), cites a case in which it is problematic whether the polyposis resulted from a bacillary dysentery or whether the dysentery was merely a complicating factor, secondary to the congenital type of polyposis of the colon. The author is of the opinion that this case was one of polyposis of the colon of the congenital disseminated type, complicated by a bacillary dysentery that confused the picture and postponed the correct diagnosis until too late for relief to be given. The pathologic specimen that confirmed the preoperative diagnosis, made possible by the roentgen study and corroborated the surgical observations, is shown.

COMMENTS UPON MEDICAL TOPICS

By MALFORD W. THEWLIS, M.D.

Classification of Nephritis. This is used in the United States Naval Medical School.

Glomerulonephritis	{ acute subacute chronic
Nephrosis	{ amyloid toxic chemical lipoid
Arteriosclerosis	{ A. Without renal insufficiency 1. cerebral symptoms 2. cardiac symptoms B. With renal insufficiency

* * *

Toxemias of Pregnancy. Strauss, Am. J. M. Sc., 765:811, 1935, believes that a manifestation of toxemia of pregnancy is water retention. This water retention probably occurs as a result, among other factors, of a lowered osmotic pressure of the plasma proteins, usually in the presence of an increased venous pressure. Results suggest that a restricted dietary intake of protein in pregnancy is harmful, and that no injurious consequences follow the administration of high-protein diets to women with toxemia of pregnancy. The beneficial results observed in these patients may well have been due to the large protein intake and to the parental administration of accessory nutritional factors. (The common prescription of "no red meats" to blood pressure and kidney patients probably does more harm than cathartics given for abdominal pain. And many patients, fearing disease, have self-inflicted low protein diets, thus often causing considerable harm.—M. W. T.)

* * *

If the lead and arsenic content of vegetables and fruits is not reduced, we may see many more cases of chronic nephritis. There are very few foods free from these chemicals.

* * *

The U. S. Supreme Court has decided that the child labor amendment is unconstitutional, so now children can return to "sweat shops." To be sure the law was badly drafted, but it is unfortunate that these youngsters can now be exploited as they were in the past.

* * *

Chest Belt for Fractured Rib. Roland Hammond, J. of Bone and Joint Surgery, 17:233-34, Jan. 1935, gives a new method of strapping the chest for fractured ribs. (A relief to be able to dispense with adhesive plaster.—M. W. T.)

The medical advice given by some manufacturers over the radio is an insult to human intelligence. Is there no way the public can be protected against such advice as is given in newspaper advertisements and on the air? Will we ever have a food and drug act which really will prevent us from having lead and arsenic foods, adulterated and decomposed food products and fake medicines?

* * *

X-ray Diagnosis of Chronic Appendicitis. According to Scholz, Am. J. Roent., 31:813, 1934, the roentgen diagnosis of appendicitis is based upon one single sign—local tenderness on palpation over the visualized appendix region. All the other so-called roentgen signs are of no diagnostic value. Scholz further states that practically every adult appendix shows microscopic anatomical changes.

* * *

Pneumococcus Typing. There is a simple procedure for typing pneumococci. It could easily be done in the office.

* * *

Occult Spina Bifida and Nocturnal Incontinence of Urine. Peritz, quoted by Berri, LaSemana Medica, shows the frequent association of these two conditions. (68% in adults and 55% in children.)

* * *

Ultra Short Wave Therapy. This is one of the newer physiotherapeutic methods and at the moment it is difficult to evaluate it. No doubt it works very well in chronic infections, but each condition requires a different wave length. The fact that the manufacturers are changing the apparatus so frequently is proof that there is still considerable work to be done.

* * *

The Treatment of Gonorrheal Arthritis by Means of Systemic and Additional Focal Heating. Bierman and Levenson, Am. J. Med. Sc., 191:55, Jan. 1936, use a combined method of water bath at a temperature of 100°-102° F. gradually raised to 107°-108° F. within an hour. A hood containing 60-watt electric light bulbs was used. Locally diathermy was administered.

* * *

The J. A. M. A., 106:71, Jan. 4, 1936, describes spectacles for those who are forced to be recumbent. It is suggested that hospitals may rent these to patients. (Why not rent radios, too?)

FISKE FUND PRIZE ESSAY, NO. LXVIII

APPENDICITIS
DIAGNOSIS, TREATMENT AND
END RESULTS

CHARLES O. COOKE, M.D. *and* J. MURRAY BEARDSLEY, M.D.

PROVIDENCE, RHODE ISLAND

"Endless is the search for truth."—STERNE

THE Trustees of the Fiske Fund, at the Annual Meeting of the Rhode Island Medical Society held at Providence, June 7, 1934, announced that they had awarded a premium of two hundred dollars to Charles O. Cooke, M.D. and J. Murray Beardsley, M.D., of Providence, Rhode Island, for an Essay entitled "Appendicitis; Diagnosis, Treatment and End Results."

CHARLES S. CHRISTIE, M.D.

ALBERT H. MILLER, M.D.

ROLAND HAMMOND, M.D.

Trustees

WILFRED PICKLES, M.D.

Secretary to the Trustees

184 Waterman Street, Providence, R. I.

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APPENDICITIS

DIAGNOSIS, TREATMENT AND END RESULTS

APPENDICITIS is the most common disease of the abdomen. It is estimated that it is responsible for about 25,000 to 30,000 deaths annually in the United States. Considerable interest has been focused upon this subject in the past few years due chiefly to the rise in the death-rate from this disease as represented by U. S. Mortality Statistics. Consequently the literature which has appeared on this subject in the past decade has been voluminous. Boland¹ states, "In the five year period, 1916 to 1920, 512 articles on appendicitis appeared in the world's literature, 209 of which dealt with acute appendicitis. From 1921 to 1925, 836 papers on the disease were printed, 308 of which concerned the acute variety. From 1926 to 1930, 1,755 papers were published, acute appendicitis being discussed in 533." According to the Quarterly Cumulative Index Medicus 251 articles on appendicitis were written in 1933.

Table I leaves no doubt in the minds of the writers as to the increase of deaths from appendicitis (and typhlitis) during the twenty year period, 1913 to 1932. In the U. S. Death Registration Area the rate increased from 12.1 in 1913 to 15.2 in 1931. Similarly, in Rhode Island, it increased from 12.3 in 1913 to 14.5 in 1931 and to 15.3 in 1932. Figure 1 pictures graphically what is also shown in Table I—that the rates for Rhode Island were somewhat lower than for the United States as a whole for more than one-half of the years in the period reviewed. The year 1924, however, showed an unusually high rate for Rhode Island—19.1.

Conclusions reached in this paper are the result of an examination of 2,405 case records at the Rhode Island Hospital. Those cases in which the appendix was removed during the course of other abdominal operations, and those in which no operation was performed, are not included. Of the cases reviewed, 1,934 were selected for study, 1,136 being of the acute variety, 693 chronic, 48 sub-acute, and 40 were cases of oxyuriasis, 23 of which were associated with chronic appendicitis. This represented all the cases operated upon for appendicitis at the Rhode Island Hospital for the five year period, 1928 to 1932, inclusive. These operations

TABLE I
DEATH-RATES FROM APPENDICITIS
AND TYPHLITIS
*Death-Registration Area in Continental U. S.
and Rhode Island*

Year	Rate per 100,000	
	United States	Rhode Island
(1)	(2)	(3)
1913	12.1	12.3
1914	12.3	12.1
1915	12.5	10.8
1916	12.8	13.6
1917	12.6	13.6
1918	12.2	9.4
1919	11.8	10.8
1920	13.4	12.2
1921	14.4	12.3
1922	14.1	15.0
1923	14.7	11.0
1924	14.8	19.1
1925	15.2	13.0
1926	15.0	14.9
1927	15.0	13.4
1928	15.3	13.7
1929	15.2	15.9
1930	15.3	15.7
1931	15.2	14.5
1932		15.3

Note: Bibliography 2 and 3

were performed on the surgical services of the hospital by twenty visiting surgeons and forty house officers, a few private cases from other services also being included. In the operations performed by the house officers, a visiting surgeon was always present at the operation.

CHRONIC APPENDICITIS

It will be seen from Table II that the incidence from chronic appendicitis is highest in the adult female group, representing 64.9 per cent. This is in contrast to the distribution in the acute group where males predominated and corresponds quite closely with other studies which include a large series of cases. Some of these cases were operated upon with a diagnosis of acute appendicitis but the pathological examination revealed a chronic process. The large majority gave no history of a previous acute attack. Also, a large number in which the diagnosis was made microscopically, showed no gross evi-

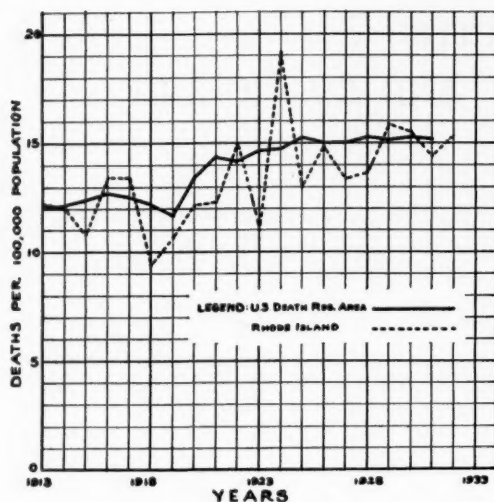


FIGURE 1. Death-rates from Appendicitis and Typhlitis
U. S. Death Reg. Area and Rhode Island, 1913-1932

dence of pathology at the time of operation. The question of chronic appendicitis is still a debatable one and it is probable that with more refined diagnosis, fewer operations will be performed for this type of disease.

TABLE II
CHRONIC APPENDICITIS

Year	Children under 13 years	Males 13 years and over	Females 13 years and over	Total	With Path. Diag.	No Path. Diag.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1928	2	30	65	97	66	31
1929	7	43	105	155	112	43
1930	8	35	82	125	108	17
1931	16	30	67	113	95	18
1932	19	53	131	203	159	44
Total	52	191	450	693	540	153
Per cent	7.5	27.6	64.9	100.	77.9	22.1

Four cases not included in the series but in which the preoperative diagnosis was chronic appendicitis are mentioned as a matter of interest. These were two cases of carcinoid of the appendix, one case of adenocarcinoma of the appendix, and one case of tuberculosis of the appendix.

There were 40 cases of appendiceal oxyuriasis, 23 of which were associated with chronic appendicitis. 62.5 per cent occurred in females. This subject is of interest because the symptoms closely simulate those of acute appendicitis in many instances. Gordon⁴ believes that the incidence is increasing. He found 1.19 per cent in his series of 26,051 appendices removed. In our series in which 1,902

appendices were removed (32 were not removed) 2.1 per cent showed oxyuriasis.

TABLE III
OXYURIASIS

Year	Chronic Appendicitis with Oxyuriasis		Normal Appendicitis with Oxyuriasis		Total Oxyuriasis	
	Male	Female	Male	Female	Male	Female
1928	1	...	...	...	1	...
1929	...	...	...	1	...	1
1930	2	5	...	...	2	5
1931	3	1	...	...	3	1
1932	4	7	5	11	9	18
	10	13	5	12	15	25
Total	23		17		40	

SUBACUTE APPENDICITIS

The diagnosis of subacute appendicitis was made in 65 cases although only 13 of these were confirmed by a pathological examination. 60 per cent occurred in females. The preoperative diagnosis in practically all of these cases was acute appendicitis.

TABLE IV
SUBACUTE APPENDICITIS

Year	Male	Female	Total	Path. Diag.	No Path. Diag.
(1)	(2)	(3)	(4)	(5)	(6)
1928	3	16	19	3	16
1929	5	5	10	3	7
1930	8	6	14	1	13
1931	5	6	11	6	5
1932	5	6	11	...	11
Total	26	39	65	13	52
Per cent	40.	60.	100.	20.	80.

ACUTE APPENDICITIS Diagnosis

The diagnosis of acute appendicitis in a typical case is not difficult. The history, physical signs and laboratory findings encountered are familiar to all physicians with ordinary training and experience. Unfortunately, a certain per cent of cases do not present the typical picture and it is here, chiefly, that errors in diagnosis occur with a resulting delay of operation, unfortunate complications and unfavorable end results. Bower⁵ finds that pain is the only constant symptom, tenderness the only physical sign usually present (in 89 per cent of cases), and that the leucocyte count is the only corroborative test (present in 80 per cent of cases).

Wilkie⁶ believes that there are two types of acute appendicitis: (1) inflammation of the wall of the

appendix which may be blood borne and follow acute tonsillitis or other infections; (2) acute appendicular obstruction which is due to a sudden and complete obstruction of the appendix. This leads to tension gangrene in from six to twenty-four hours, followed by perforation and the escape of fecal contents into the peritoneal cavity. It is frequently difficult, therefore, though extremely important to make an early diagnosis in this variety of acute appendicitis. The pain is usually severe and colicky in character, the temperature as a rule is not elevated, and tenderness and spasm are not marked in the early hours of the disease. The leucocyte count is usually elevated. Clute⁷ and others agree with Wilkie's observations and have published results confirming them.

We have attempted to concentrate our attention upon those factors in diagnosis which have appeared to us to be of most importance in influencing the end results. Perhaps the two which should be especially mentioned are: (1) delay in diagnosis as represented by the number of hours ill before operation was performed; (2) failure of diagnosis as evidenced by the administration of cathartics. It was estimated that the usual symptoms of pain, nausea or vomiting, and the physical signs of tenderness and spasm, and elevation of pulse and

temperature were present in about 80 per cent of our cases. But it was felt that no useful purpose would be accomplished by recording in detail these data which are well known to all those familiar with this disease.

Sex

That acute appendicitis is more common in males than in females is a fact noted by many observers. Walker's⁸ early series (1907-10) showed 63 per cent males, and the later series (1927-30) 60.8 per cent males. Boland, Finney⁹ and others all show a preponderance of males. The 61 per cent of males in this series as represented in Table V would appear to be an average sex distribution, with no wide variation by years.

TABLE V
ACUTE APPENDICITIS
Incidence according to Sex

Year	Male		Female		Total
	No.	Per cent	No.	Per cent	
1928.....	111	57.8	81	42.2	192
1929.....	107	58.5	76	41.5	183
1930.....	146	61.6	91	38.4	237
1931.....	144	65.2	77	34.8	221
1932.....	185	61.1	118	38.9	303
Total.....	693	61.0	443	39.0	1,136

TABLE VI
ACUTE APPENDICITIS
Incidence according to Age

Year	Age-group											Total
	0-5	6-10	11-15	16-20	21-30	31-40	41-50	51-60	61-70	71-	N. S.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1928.....	9	26	44	43	27	16	13	5	6	1	2	192
1929.....	7	28	40	35	32	17	17	4	3	0	...	183
1930.....	14	33	47	45	42	24	19	7	5	1	...	237
1931.....	15	43	41	43	31	18	17	10	2	1	...	221
1932.....	11	37	60	63	66	30	19	10	6	1	...	303
Total.....	56	167	232	229	198	105	85	36	22	4	2	1,136
Per cent.....	4.9	14.7	20.4	20.2	17.4	9.2	7.5	3.2	1.9	0.4	0.2	100.

Age

Table VI finds 40.6 per cent of all cases falling in the second decade, the next highest incidences occurring in the first and third decades respectively. This corroborates the findings of most observers that acute appendicitis is a disease of early life with the peak in this series falling in the 11 to 15 year age-group. After the second decade the incidence declines in direct proportion to the advance in years.

Hours Ill Before Operation

Table VII illustrates the duration of attack before operation was performed. It will be seen that 55.2 per cent were admitted after 24 hours of illness. Of the 16.8 per cent that were admitted within the first twelve hours, only 3.3 per cent entered the hospital within the first six hours. There is definite improvement in early admissions during the later years, 13.0 per cent in 1928 being

admitted before twelve hours as contrasted with 23.4 per cent in 1932. In 1928, 14.1 per cent of cases were operated after four days of illness while in 1932 only 3.7 per cent were admitted at this late date.

TABLE VII
ACUTE APPENDICITIS
Hours Ill before Operation

Year	Per cent of cases					Hours N. S.
	0-12 hours	13-24 hours	25-48 hours	49-96 hours	97- hours	
1928	13.0	22.9	39.6	9.9	14.1	0.5
1929	12.0	25.1	42.1	9.3	10.9	0.6
1930	16.9	28.3	37.9	7.2	9.3	0.4
1931	14.9	30.3	43.5	6.8	4.5	.....
1932	23.4	31.0	34.3	6.3	3.7	1.3
Total	16.8	28.0	39.0	7.7	7.9	0.6

Cathartics

In 19.4 per cent of 1,136 cases of acute appendicitis it was specifically stated that patients received

cathartics, although it is very probable that many more were received than were actually recorded. The laxatives most commonly used were:

salts
castor oil
castoria
cascara pills
senna leaves
ex-lax

In this series the number of laxatives given during the two latter years was less than in the first three years, and it is to be hoped that this is an indication that the laity are becoming more aware of the danger of laxatives in acute abdominal conditions. Table VIII shows very clearly the unfavorable influence of catharsis in acute appendicitis as represented by the increased number of perforations and deaths.

TABLE VIII
ACUTE APPENDICITIS

Effect of Cathartics on Perforations and Deaths

Year	Total	Per cent	CATHARTIC				Total	No CATHARTIC			
			Ruptured		Not Ruptured			Ruptured		Not Ruptured	
			Living	Dead	Living	Dead		Living	Dead	Living	Dead
1928	38	19.8	24	1	13	...	154	61	12	81	...
1929	39	21.3	14	4	21	...	144	47	8	88	1
1930	49	20.7	28	2	18	1	188	47	6	132	3
1931	30	13.6	17	3	9	1	191	59	12	120	...
1932	64	14.5	36	5	23	...	239	54	7	177	1
Total	220	19.4	119	15	84	2	916	268	45	598	5
Per cent	100.	...	54.1	6.8	38.2	0.9	100.	29.3	4.9	65.3	0.5

Summary: 19.4 per cent of all cases received cathartics.

Cathartics

60.9 per cent were ruptured.
7.7 per cent died.

No Cathartics

34.2 per cent were ruptured.
5.4 per cent died.

TABLE IX
ACUTE APPENDICITIS
Leucocyte Count

Year	-10,000	11-13,000	14-17,000	18-21,000	22,000-	Total
1928	11	15	27	31	12	96
1929	10	19	38	26	23	116
1930	12	34	42	34	29	151
1931	12	25	36	35	30	138
1932	20	36	69	44	29	198
Total	65	129	212	170	123	699
Per cent	9.3	18.5	30.3	24.3	17.6	100.

Leucocyte Count

The leucocyte count was recorded in 699 of the 1,136 cases. At the Rhode Island Hospital the leucocyte and polymorphonuclear count are done as a routine in all ward cases in which an acute abdominal condition is suspected. A large number in which the white blood count was not stated were private cases, many of which had had it done before coming to the hospital. In many others, although the count was done, the interne had neglected to enter it in

the record. In Table IX the leucocyte counts performed are recorded by years but no attempt was made to differentiate according to the type of appendix found at operation. It will be seen that 90.7 per cent of all counts were 11,000 and over, with the highest percentage (30.3 per cent) falling between 14,000 and 17,000. We may infer from this that the leucocyte count was of aid in establishing the diagnosis in over 90 per cent of the cases in which it was performed. The polymorphonuclear count was not analyzed in detail but it is estimated that it was elevated in between 80 to 90 per cent of the acute cases.

Type of Appendix

The 1,136 cases included in the acute series were divided into:

1. Not ruptured
2. Ruptured with abscess
3. Ruptured with peritonitis

TABLE X
ACUTE APPENDICITIS
Incidence according to Type

Year	Not Ruptured		Ruptured with abscess		Ruptured with peritonitis		Total
	No.	Per cent	No.	Per cent	No.	Per cent	
1928	94	49.0	30	15.6	68	25.4	192
1929	110	60.1	26	14.2	47	25.7	183
1930	154	65.0	27	11.4	56	23.6	237
1931	130	58.8	16	7.3	75	33.9	221
1932	201	66.3	25	8.3	77	25.4	303
Total	689	60.7	124	10.9	323	28.4	1,136

In the "not ruptured" group a large number were gangrenous and in many of these and in others, free fluid was present but the cultures were sterile. In the ruptured cases, those recorded as "ruptured with abscess" showed definite evidence of a walling off process, while the remainder exhibited signs of spreading or generalized peritonitis. In the acute series 39.3 per cent of all cases were ruptured before operation. This figure is higher than is usually found although some writers include subacute cases in their total. Finney⁸ states that "almost 20 per cent of inflamed appendices have ruptured when they reach the surgeon." It would seem, therefore, in this series, that the surgeons were dealing with a more unfavorable group of cases than is the rule. Of the 39.3 per cent of ruptured cases there was

evidence of abscess formation in 10.9 per cent while 28.4 per cent exhibited signs of spreading or generalized peritonitis.

Organisms from Positive Cultures

Cultures were taken routinely in all cases where free fluid or an abscess was present. There were 244 reports of cultures recorded and of these 82 per cent showed colon bacillus, 30.8 per cent of which were associated with pneumococcus (Table XI). It is interesting to note the presence of pneumococcus in such a large number, while *B. coli* in pure culture, and streptococcus might be expected to have been present in a higher per cent of cases.

TABLE XI
ACUTE APPENDICITIS
Organisms from Positive Cultures

Year	CULTURE				Total
	B. Coli & Pneumo-coccus	Strepto-coccus	B. Coli	Others	
1928	19	2	10	6	37
1929	7	5	18	5	35
1930	24	2	24	6	56
1931	20	1	37	2	60
1932	5	4	36	11	56
Total	75	14	125	30	244
Per cent	30.8	5.7	51.2	12.3	100.

Differential Diagnosis

It is not our purpose to go into a discussion of the several scores of conditions that may be confused with acute appendicitis and discuss the differential diagnosis in each instance. We have attempted in the main to confine our remarks in this paper to observations noted in our own series. We will mention briefly a few conditions where mistakes in diagnosis most commonly occurred.

There were several cases of acute appendicitis of the Wilkie variety in which the physician was misled by the character of the pain, absence of fever, and the late development of tenderness and spasm. The majority of these cases were ruptured on admission. A more thorough knowledge of this condition and a leucocyte and a polymorphonuclear count would have avoided a certain number of perforations and deaths.

In females acute salpingitis, as may be expected, was confused with the diagnosis in the largest number of instances. All surgeons are familiar with the points of differential diagnosis in these two condi-

tions. Acute salpingitis is usually associated with higher temperature and white blood count, and pain and rigidity are out of proportion to the apparent gravity of the situation. Careful abdominal and pelvic examination and the sedimentation time should usually establish the diagnosis when urethral and cervical smears are negative.

The diagnosis of acute appendicitis in young children is frequently difficult, the diseases with which it was most commonly confused being intestinal colic, acute pulmonary conditions, pneumococcus peritonitis and intestinal obstruction from different causes. Pyelitis, although simulating acute appendicitis in many instances, was usually diagnosed when a microscopic examination of the urine was made. It is believed that co-operation of the pediatrician and surgeon is of value in establishing a diagnosis in obscure cases in children with an acute abdominal condition.

The too frequent confusion of lobar pneumonia with acute appendicitis in this series recalls the adage of Osler that "The examination of an abdomen begins at the chin and ends at the knees." Probably the majority of surgeons do not do a thorough examination of the chest when called to see a patient suffering from abdominal pain. It is impracticable to have a medical consultation in the great majority of acute cases and the surgeon must, therefore, hold himself personally responsible for pathology above the diaphragm as well as within the abdominal cavity.

There were no other common errors in diagnosis worthy of note.

Treatment

In this series treatment consisted of immediate operation as soon as the diagnosis was established, except in an occasional case that arrived in the hospital in an extreme condition, or with marked dehydration, when there was a slight delay in an attempt to increase the general resistance and make it a safer surgical risk by means of intravenous saline, glucose or other necessary medication. We do not believe in the Ochsner method of treatment as two probable cases not included in this study, in which it was tried, did not respond and died without operation.

Anesthesia

Nitrous oxide-ether anesthesia was employed in practically all cases, a few surgeons using novo-

caine in conjunction in order to render less the amount of ether given, and to promote more satisfactory relaxation. In cases where ether appeared to be contraindicated because of the presence of colds, pulmonary disease, renal affections and other diseases, spinal anesthesia was the usual choice, although avertin was used in a few instances, supplemented by novocaine or nitrous oxide.

Incision

The right rectus incision was almost universally used in the 1,136 operative cases in the acute group, the great majority being of the muscle splitting variety. Other incisions used were—17 McBurney, 2 median, and in one the type of incision was not stated.

Treatment of the Stump

It was the policy to bury the stump, either by purse string or by interrupted sutures, in all cases where this was possible. Table XII shows that there were 94 cases in which the stump was not buried. We do not feel that the 13 deaths indicated in the table are attributable to the fact that the stump was not buried but rather to the severity of the disease that prevented it from being accomplished. In some cases the stump was covered with meso-appendix or omentum where it was impossible to bury it.

TABLE XII
ACUTE APPENDICITIS
Cases in which the Stump was not Buried

Year	Stump Not Buried		
	Living	Dead	Total
1928.....	16	6	22
1929.....	10	4	14
1930.....	16	...	16
1931.....	12	1	13
1932.....	27	2	29
Total.....	81	13	94

Drainage

Drainage was instituted at the discretion of the individual surgeon. There were a few cases in which it was considered that drainage was done unnecessarily, where the culture was sterile and there was very little apparent evidence of spreading infection. One is not justified, however, in making this decision from the mere study of the record.

When drainage has been instituted we believe that the drain or drains should be left in place,

without being disturbed, for at least seven days. This gives more time for protective adhesions to form and when the drain is removed the sinus will not collapse. Too early removal of drains frequently gives rise to abscess pockets along the course of the sinus.

Post-operative Care

This very important phase in the treatment of the patient is not notable in this series for any new departures or radical ideas, but was carried out along orthodox lines, and in spite of the large number of surgeons operating there was considerable uniformity in the post-operative handling of the cases. As a rule morphine was given freely within the first forty-eight hours, when necessary. Probably the majority received rectal tap water immediately after operation which was continued every four to six hours for a variable length of time. Enema was the rule on the third or fourth post-operative day. Perhaps special mention should be made of the life saving value of the Levine tube in those cases complicated by persistent vomiting or paralytic ileus. There were 8 cases in which jejunostomy was performed for intestinal obstruction, 3 of which recovered and 5 died. Clyses and intravenous therapy were used freely in all post-operative cases with marked infection and dehydration. The Fowler position was generally employed.

It will be noted in Table XIII that in 1928, 38 per cent of cases were discharged from the hospital within 15 days, and that in 1932, 61.7 per cent of cases were discharged during this same period. Likewise, in 1928, 15 per cent had a hospital stay of 31 days and over, while only 4.3 per cent remained for that length of time in 1932. This table would seem to indicate a tendency to an earlier discharge in later years, although this is probably influenced by the larger number of ruptured cases that were admitted in 1928.

TABLE XIII
ACUTE APPENDICITIS

Days' Hospitalization

Year	Per cent of cases					
	0-10 days	11-15 days	16-20 days	21-25 days	26-30 days	31- days
1928	9.4	28.6	21.9	18.8	6.3	15.0
1929	7.1	33.3	23.5	17.5	5.5	13.1
1930	10.1	43.5	22.4	7.6	5.0	11.4
1931	9.5	36.2	22.6	8.6	10.4	12.7
1932	10.6	51.1	17.2	9.9	6.9	4.3
Total	9.5	40.0	21.1	12.7	7.4	9.3

End Results

Of the 1,934 cases operated on at the Rhode Island Hospital for the five year period, 1928 to 1932, inclusive, there were 71 deaths, a mortality rate for the entire series of 3.67 per cent. In the cases of chronic appendicitis (693), and chronic appendicitis with oxyuriasis (23), there were 4 deaths, a mortality rate of 0.56 per cent. There were no deaths in the subacute group (65), or in those cases diagnosed pathologically "normal appendix with oxyuriasis" (17). The mortality for this series of appendectomies in which there was no acute process, was 0.50 per cent. Walker⁸ found that "the mortality rate in chronic appendicitis appears to be between .5 per cent and 1 per cent at the present time." Of the 4 deaths in chronic cases—

TABLE XIV
MORTALITY RATES BY GROUPS

Type	Number	Deaths	Mortality Per cent
Acute	1,136	67	5.89
Chronic	693	3	} 0.56
Chronic with oxyuriasis	23	1	
Normal with oxyuriasis	17	...	
Subacute	65	...	
Total	1,934	71	3.67

1 died of generalized peritonitis;

1 died of scarlet fever;

2 died of lobar pneumonia.

Of the 1,061 cases of acute appendicitis that recovered, 75 or 7.1 per cent developed complications as follows:

Lobar pneumonia	21
Bronchopneumonia	2
Abscess	
residual	12
pelvic	3
subphrenic	1
abdominal wall	2
perinephritic	1
Phlebitis (femoral)	4
Parotitis	3
Hemorrhage	2
Diphtheria	2
Psychosis	2
Ileus	4
Fecal fistula	4
Empyema	1
Gangrene of left leg	1
Pyelitis	1
Pulmonary embolism	1
Catarrhal jaundice	1
Scarlet fever	1
Rupture of wound	3
Acute bronchitis	1
Total	75

There were 67 deaths in the total 1,136 acute cases, a mortality rate of 5.89 per cent. Table XV represents the mortality rate as it occurred by years. It will be noted that it was highest in 1931 (7.24) and lowest in 1932 (4.29). In the series of 33,000 cases collected by Walker the mortality was 5.3 per cent.

TABLE XV
ACUTE APPENDICITIS
Mortality by Years

Year	Number of cases	Deaths	Mortality Per cent
1928	192	13	6.77
1929	183	13	7.10
1930	237	12	5.06
1931	221	16	7.24
1932	303	13	4.29
Total	1,136	67	5.89

TABLE XVI
ACUTE APPENDICITIS
Incidence and Mortality according to Age

(1)	AGE-GROUP								Not Stated (10)	Total (11)
	1-10 (2)	11-20 (3)	21-30 (4)	31-40 (5)	41-50 (6)	51-60 (7)	61-70 (8)	71- (9)		
Number of cases	223	461	198	105	85	36	22	4	2	1,136
Deaths	14	15	10	5	10	6	6	1	..	67
Mortality Per cent	6.3	3.3	5.1	4.8	11.8	16.7	27.3	25.0	...	5.89
Incidence of deaths	20.9	22.4	14.9	5.7	14.9	9.0	9.0	1.4	...	100.0

Mortality According to Hours Ill Before Operation

The effect of operative delay upon mortality is clearly indicated in Table XVII. Those cases operated on before 12 and 24 hours had a mortality of 2.1 per cent and 2.8 per cent, respectively, while 21.8 per cent and 18.8 per cent died between 48 and 96 hours and 97 hours and over, respectively. This corresponds with the findings of Muller¹⁰ who had a mortality of 2.55 per cent and 2.56 per cent in cases admitted before 24 hours. His mortality after 72 hours was 11.83 per cent and 10.42 per cent. This illustrates the well known fact that delay of operation is the most important factor in increasing the mortality in acute appendicitis.

Mortality According to Age

Of the 1,136 cases of acute appendicitis, 882 or 77.6 per cent occurred in the first three decades. Out of this number there were 39 deaths or 58.2 per cent of the total. A study of the mortality for each age group as shown in Table XVI indicates that the chances for survival seem to be greatest in the second decade where the rate is 3.3 per cent. From this point onward there is practically a steady rise in the mortality, the peak being reached with 27.3 per cent between the ages of 61 to 70. It is generally conceded that diagnosis is more difficult in young children. There is also a greater tendency to the administration of laxatives and other medication before medical aid is sought. It is felt that these two factors are to a certain degree responsible for the 6.3 per cent mortality rate that occurred in the first age group.

TABLE XVII
ACUTE APPENDICITIS
Deaths according to Hours Ill before Operation

Year	HOURS ILL					Not Stated (7)	Total (8)
	0-12 (2)	13-24 (3)	25-48 (4)	49-96 (5)	97- (6)		
1928	..	..	6	4	3	...	13
1929	1	2	4	4	2	...	13
1930	2	3	2	2	3	...	12
1931	..	3	3	5	5	...	16
1932	1	1	3	4	4	...	13
Total Deaths	4	9	18	19	17	...	67
Total Cases	191	318	443	87	90	7	1,136
Mortality Per cent	2.1	2.8	4.1	21.8	18.8	...	...

Mortality in Ruptured and Not Ruptured Cases

A total of all ruptured cases gave a mortality of 13.4 per cent as contrasted with 1.0 per cent in not ruptured cases, as shown in Table XVIII.

TABLE XVIII
ACUTE APPENDICITIS

Mortality in Ruptured and Not Ruptured Cases

Type	Cases		Deaths		Mortality Per cent
	No.	Per cent	No.	Per cent	
(1)	(2)	(3)	(4)	(5)	(6)
Ruptured	447	39.3	60	89.6	13.4
Not Ruptured	689	60.7	7	10.4	1.0
Total	1,136	100.0	67	100.0	5.89

Of the 67 deaths in the acute series their status on admission was as follows:

- (1) 39 were ruptured with generalized peritonitis.
- (2) 21 were ruptured with abscess.
- (3) 7 were not ruptured.

All of these cases except 5 of the "not ruptured" died with generalized peritonitis, the causes of death in these 5 being:

lobar pneumonia	2
general sepsis	1
residual abscess (not drained)	1
pulmonary embolism	1

The remaining complications in each group were:

Ruptured with General Peritonitis

Ileus	5
Ileus	
Bronchopneumonia	1
Ruptured wound	
Lobar pneumonia	2
Hemorrhage	1
Lobar pneumonia	1
Uremia	3

Ruptured with Abscess

Ileus	1
Lobar pneumonia	3
Lobar pneumonia	
Nephritis	1
Bronchopneumonia	1
Otitis media	
Abscess (subdiaphragmatic)	1
Uremia	1
Atelectasis	1
Cardiac decompensation	1

Not Ruptured

Bronchopneumonia	1
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SUMMARY

1. Of the 1,934 cases operated upon for appendicitis at the Rhode Island Hospital during the five year period, 1928 to 1932, inclusive, the distribution was as follows: 1,136 acute, 693 chronic, 23 chronic with oxyuriasis, 17 normal with oxyuriasis and 65 subacute.

2. The preponderance of chronic and subacute cases was in females; and of the acute, in males.

3. 77.6 per cent of all acute cases were under 30 years of age.

4. More than one-half of the cases (55.2 per cent) were operated on after 24 hours of illness.

5. In those cases in which cathartics were given, 60.9 per cent were ruptured and 7.7 per cent died. In cases that received no cathartic, 34.2 per cent were ruptured and 5.4 per cent died.

6. The leucocyte count was 11,000 or over in 90.7 per cent of the cases.

7. In the acute cases, 60.7 per cent were not ruptured, 10.9 per cent were ruptured with abscess, and 28.4 per cent were ruptured with peritonitis.

8. Of the cultures recorded in 244 cases, the colon bacillus predominated.

9. In the acute cases treatment consisted of immediate operation as soon as the diagnosis was established.

10. About one-half of the cases were discharged within 15 days.

11. In the fatal cases, complications occurred in 40.7 per cent and in those that recovered, 7.1 per cent.

12. The mortality increased with the advance in age.

13. Operative delay increased the rate of mortality.

14. The mortality rate in ruptured cases was 13.4 per cent, and in not ruptured cases, 1.0 per cent.

15. The mortality rate for acute cases was 5.89 per cent.

The mortality rate for the combined chronic, subacute and oxyuriasis cases was 0.50 per cent.

The mortality rate for the entire group was 3.6 per cent.

CONCLUSION

The mortality in acute appendicitis is due to three factors:

1. Delay in diagnosis
2. Administration of cathartics
3. Faulty surgical management

Delayed diagnosis is due to several factors, the most important of which is the failure to call the family physician at the onset of the disease. With increased skill of the modern physician, the diagnosis as a rule can be promptly made. The administration of morphine to relieve pain before the diagnosis is made is another factor in delay. Morphine masks the symptoms and should never be given until the diagnosis of appendicitis has been made or excluded.

Catharsis stimulates peristalsis and causes rupture of the appendix. Cathartics should never be administered, therefore, until appendicitis has been ruled out.

Faulty surgical management applies to operative technique, the question of drainage and the after care of the patient. The operative mortality of experienced surgeons is not increasing. It is doubtless increasing in the hands of the occasional operator. The operation for acute appendicitis should only be performed by men who have had adequate experience in abdominal surgery.

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